DEHYDRATION FLUIDIZED BED

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(54) FLUIDIZED BED APPARATUS

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IMPROVEMENT IN FLUIDIZED BED APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to fluidization apparatus, and more particularly, to an improved apparatus for carrying out fluidized bed operations.

Fluidized bed equipment has been used for many years in the chemical industry for carrying out a wide variety of chemical reactions and unit operations such as drying. In the usual fluidized bed, a solid phase is suspended in an upwardly moving fluid stream, usually a gas stream, whereby the mass of solid particles behaves somewhat like a boiling liquid. The solid phase may be a catalyst to promote a chemical reaction in the stream of fluidizing gas, or it may be a material reactive with the fluidizing gas. Alternatively, the solid phase may be a material which is treated by the fluidizing gas as in the case of fluidized drying.

One of the primary advantages of fluidized bed systems arises from the fact that the high turbulence created in the bed provides high heat transfer characteristics as well as complete mixing of the solids and gases within the bed itself.

Fluidized bed systems are, however, not without disadvantages. One of the disadvantages of fluidized bed systems known to those skilled in the art is the formation of "dead zones" at the upper portion of the reactor where the solids may lay and be subjected to high temperatures for extended periods. With some solids, such as starch, auto ignition can occur, causing fire and explosions. This problem has been overcome in the prior art by mechanical means such as the impeller disclosed in U.S. Patent No. 4,075,766. In addition, fluidized beds are often

characterized by a phenomenon known as channeling whereby gas pockets are formed within the solids phase such that gases travel through the fluidized bed without intimately contacting the solid phase. Both of these problems are recognized in the art as severe in the fluidization of solid phases which are difficult to fluidize, notably starch.

Significant improvements in the fluidization of solids which are difficult to fluidize have been achieved through the use of fluidization processes and apparatus as described in U.S. Patent Nos. 3,967,975 and 4,021,927. An improvement on said patents is also described in our Canadian patent no. 1,124,058 issued May 25, 1982. The fluidized bed system utilized in these patents comprises three distinct fluidized zones including upper and lower fluidized zones, each of which is provided with paddle type agitators to promote more complete mixing. The upper and lower fluidized zones communicate with each other by means of a plurality of tubular zones surrounded by heat transfer media whereby most, if not all, of the heat transfer to or from the fluidized bed is passed through the walls of the tubular fluidized zones.

The present invention is an improvement in fluidized bed reactors which provides for the elimination of flat surfaces in the lower, generally horizontal portion of the upper chamber to prevent formation of "dead zones" and thereby eliminate the need for mechanical means to keep the chamber free from fluidizable materials that may otherwise lay in said chamber.

SUMMARY OF THE INVENTION

The present invention is directed to apparatus for fluidization of solid materials, particularly solid particulate materials which have ....

a tendency to adhere or agglomerate. The apparatus of the present invention is useful in chemical and physical processes in which such particulate materials are fluidized and subjected to heat transfer during fluidization, usually to supply heat to the particulate material.

In accordance with one embodiment of the invention, the improved apparatus includes a fluidization system comprising an upper agitated fluidized zone and a lower agitated fluidized zone with an intermediate fluidized zone formed of a plurality of tubular zones communicating with each of the upper and lower fluidizing zones whereby fluidizing gas is passed upwardly through the lower agitated fluidized zone, through the intermediate zone, and into the upper agitated fluidized zone to fluidize the solids in each of the three zones. The improvement afforded by way of this invention resides in a spacing means provided in the upper fluidized zone, said spacing means having a multiplicity of tapered openings wherein said openings are coterminous on the upper surface of said spacing means and spaced on the lower surface of said spacing means. Said openings on the lower surface are in concentric communication with the open ends of said tubes in the upper chamber, thereby communicating the interior of said tubes with the upper chamber.

The improvement of the present invention can be adapted to other types of fluidizing apparatus having a plurality of tubular zones, the open ends of which communicate the interior of said tubes with an upper chamber.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a sectional view of a fluidized bed apparatus embodying the features of the present invention.

FIGURE 2 is a sectional view along the line 2-2 in FIGURE 1.

FIGURE 3 is a sectional view taken along the line 3-3 in FIGURE 2.

The apparatus of the present invention is ideally suited for use in the conversion of starch to dextrin. However, as will be appreciated by those skilled in the art, the apparatus of this invention is likewise suitable for a variety of other fluidized bed applications including fluidized drying, petroleum cracking operations and the like where fluidized bed systems have been used in the past. For ease of illustration, the apparatus of the invention will hereinafter be described in conjunction with the conversion of starch to dextrin, with the understanding that it may similarly be used for many other fluidized operations.

Referring now to FIGURE 1, there is shown in detail a cross sectional view of a fluidized apparatus of this invention. The apparatus includes an elongate vertical housing designated as 10 which defines in its upper portion, an upper chamber 12 having inlet means 14 to supply a fluidizable material thereto. The housing 10 also defines a lower chamber 16 positioned at substantially the bottom. Both of the upper chamber 12 and the lower chamber 16 include agitator means 18 and 20, respectively. The agitator means 18 includes a shaft 22 mounted for rotation within the upper chamber 12. Mounted on shaft 22 for rotation therewith are a plurality of blades 24 which may be in the form of flat paddles rotatable with the shaft 22. The agitator means 20 in the lower chamber 16 similarly includes a rotatable shaft 26 having substantially flat blades mounted for rotation therewith.

The agitating means 18 is formed with flat blades 24 at staggered locations, with additional flat blades 30 being mounted at a 90° angle between each of the blades 24. These blades present a substantially flat surface lying in a plane transverse to the direction of flow of the fluidizing gas. The agitating means 20 in the lower

chamber 16 has a similar configuration. Some or all of the blades can be disposed at angles with respect to those illustrated.

Positioned in the housing 10 in an intermediate section 32 are a plurality of tubes 34 having upper ends 36 communicating with the upper chamber 12 and lower ends 38 communicating with the lower chamber 16. The upper ends 36 are in concentric communication with tapered openings 71 on the lower surface of spacing means 70. In this way, fluidizable material introduced to the inlet 14 flows by gravity downwardly through the upper chamber 12 through the plurality of tubes 34 and into the lower chamber 16. The lower chamber 16 also includes outlet means 40 to withdraw fluidizable material therefrom.

Positioned below the lower chamber 16 is a housing 42 defining a plenum chamber 44. Fluidizing gas is introduced to the plenum chamber through fluidizing gas inlet means 46, and passes through a foraminous distributor plate 48 into the lower chamber 16.

The arrangement of the tubes in the intermediate section 32 can be varied considerably. One suitable arrangement for the tubes 34 in the section 32 is shown in FIGURE 2 of the drawing. As shown in this figure, the tubes 34 are arranged in a pattern about the center of the section 32.

At least the tubular section is provided with means to supply or remove heat therefrom. For this purpose, the section 32 preferably defines a jacket for heat exchange media which can be supplied to the section 32 by inlet means 49 and removed from the section or jacket 32 by outlet means 50 as shown in FIGURE 1. It is also desirable in many instances to employ heat exchange means with the upper and lower chambers. For this purpose, it is generally sufficient to provide a jacket 52 sur-

er chamber 12, with the jacket 52 including inlet means t exchange media to the jacket 52 and outlet means 56 xchange media from the jacket 52.

s shown in FIGURE 1 of the drawing, it is sufficient that e jacket 52 for the upper chamber 12 extend only up to 14. In the illustrated embodiment, the upper chamber 12 dome portion 58 from which the fluidizing gas may be reactor by means of outlet means 60. As will be hose skilled in the art, not only is the fluidizing gas removed from the outlet means 60, but any "fines" entrained in the fluidizing gas are carried out with it through the outlet means 60. It is possible, and sometimes desirable, to form the upper chamber with an increased sectional area to reduce the linear velocity of the fluidizing gas to thereby assist in the separation of entrained particles of the solid phase. The cross sectional area of the dome itself may be increased or the cross sectional area of the entire chamber 12 may be increased for this purpose.

The lower chamber 16 may likewise be provided with heat exchange media, such as in the form of a jacket 62, to which heat exchange media is supplied through inlet means 64 and from which the heat exchange media can be removed from outlet means 66.

FIGURES 2 and 3 illustrate the improvement claimed in the present invention. Spacing means 70 is provided with tapered openings 71. On the upper side of spacing means 70, tapered openings 71 are coterminous at junctures 72. The diameters of tapered openings 71 are gradually decreased from the upper side of spacing means 70 to the lower side of spacing means 70 whereon said tapered openings 71 are spaced. At the junction of upper housing 12 with the outer edge 73 of spacing means 70 it is preferable to provide a tapered section 74.

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The objective of the present invention is to eliminate generally horizontal flat surfaces in the upper chamber. This prevents formation of the "dead zones" defined in the present application. The objective is achieved by the design illustrated in FIGURES 2 and 3 as described above.

In carrying out a process utilizing the apparatus of the present invention, use can be made of a wide variety of starches in the conversion of such starches to dextrin. For example, starch can be blended with an acid catalyst, preferably HCl, for supply to the fluidized bed reactor of the invention. For this purpose, it is generally preferred to use acid in an amount ranging from 0.01 to 10.0 parts by weight of 20° Be' HCl per 1000 parts by weight of starch d.b. This corresponds approximately to average paste acidities expressed as milliequivalents of acid per gram of starch (dry bases) of 0.001 to 0.10.

The acidified starch is then passed through the apparatus while maintained at a temperature which is dependent somewhat on the type of dextrin to be produced. In general, the starch is maintained at a temperature within the range of 200°-400°F in the fluidized bed reactor. In general, the residence time of the starch in the fluidized bed reactor of this invention is less than one hour, and most frequently ranges from 10 to 30 minutes, although longer or shorter residence times may be employed depending somewhat on the grade of dextrin desired and the degree of conversion sought.

If desired, the air fluidizing gas may be heated, depending on the grade of dextrin to be produced. In general, the air can be heated to a temperature within the range from 85°F to 350°F. For example, when canary dextrin is to be produced, temperatures within the range of 225°-310°F are usually preferred. The air supplied as the fluidizing gas preferably

contains moisture to more efficiently promote the conversion reaction. In general, the air should have a relative humidity within the range of 15 to 80%, depending, again, on the grade of dextrin to be produced and the temperature of the air. In this way, the introduction of water or acid catalyst directly onto the starch in the fluid bed reactor can be avoided, thereby further reducing any tendency for the starch to agglomerate.

As will be appreciated by those skilled in the art, other fluidizing media can be used. For example, steam, or inert gases such as nitrogen, carbon dioxide, etc., preferably containing some moisture can be used. In addition, flue gases from combustion operations can similarly be used as the fluidizing medium if desired. It is not essential that the fluidizing medium add any sensible heat to the starch undergoing dextrinization since the tubular section of the reactor employed with the concepts in the practice of this invention in the dextrinization of starches is capable of providing all of the heat necessary to efficiently effect the reaction.

The improvement in the apparatus described above can be used in other fluidized apparatus by those skilled in the art.

Having set forth the general nature and some specific embodiments of the present invention, the scope of the invention is now particularly pointed out in the appended claims.

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THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. Apparatus for carrying out fluidized operations on starch comprising an elongate generally upstanding housing, said housing defining an upper chamber, an intermediate chamber and a lower chamber wherein said upper chamber and said lower chamber are each provided with agitating means which include rotatable agitator blades, a plurality of open ended tubes positioned inside the intermediate chamber, the open ends of each of said tubes communicating the interior of said tubes with said upper and lower chambers, respectively, wherein starch passes from said upper chamber through said tubes into said lower chamber, the improvement comprising

spacing means provided in said upper chamber, said spacing means having a plurality of tapered openings wherein said openings are coterminous on the upper side of said spacing means and spaced on the lower side of said spacing means, said openings on said lower side being in concentric communication with the open ends of said tubes in said upper chamber, thereby communicating the interior of said tubes with said upper chamber wherein downwardly tapered means are provided at the upper interior junction of said spacing means with said housing.

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FIG. 1

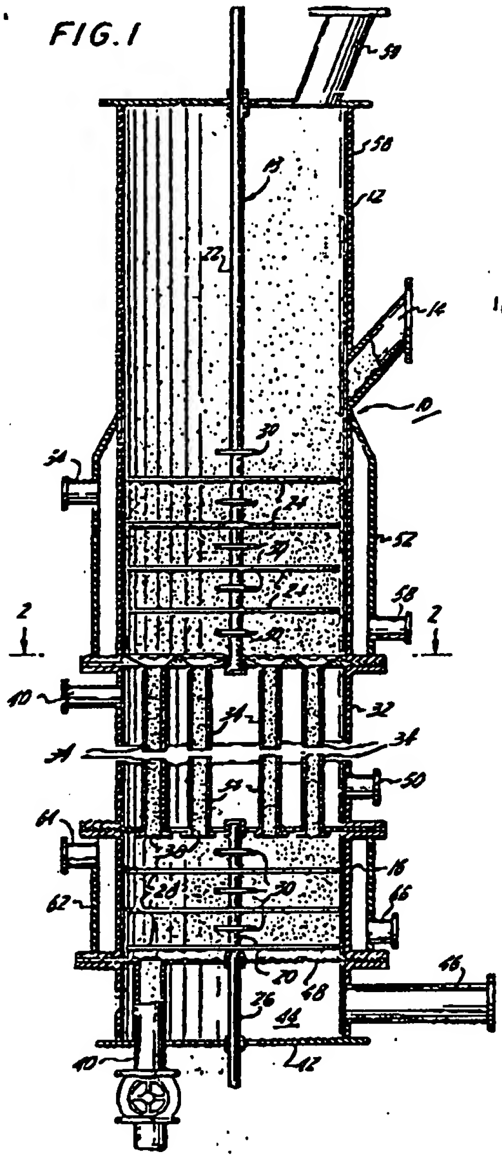

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FIG. 2

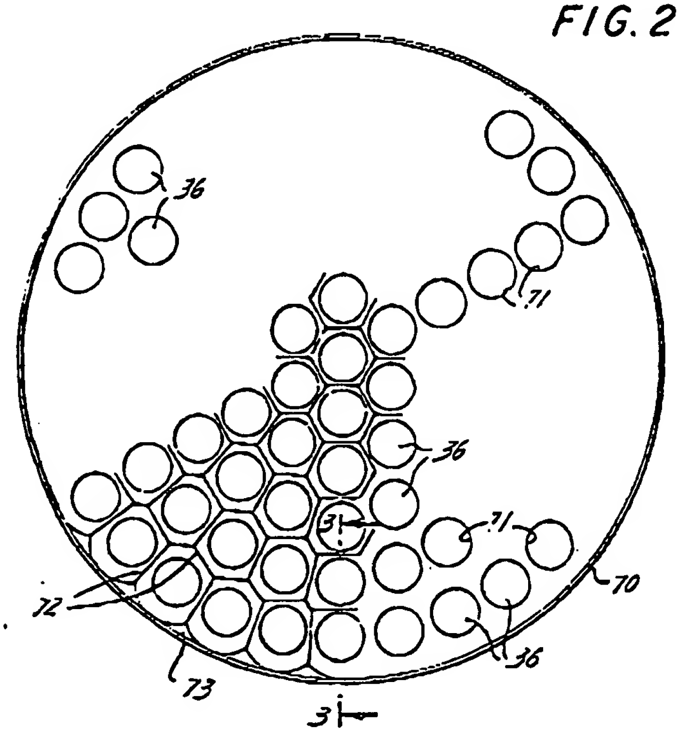
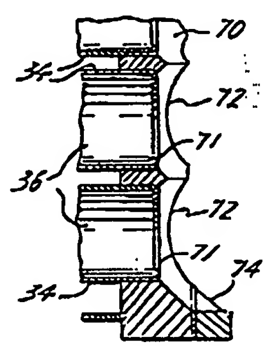


FIG. 3



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